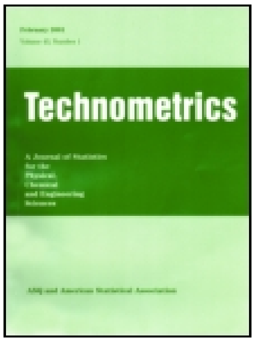

Technometrics

ISSN: 0040-1706 (Print) 1537-2723 (Online) Journal homepage: https://www.tandfonline.com/loi/utch20

Bootstrap Methods: A Practitioner's Guide

James T Wassell

results can be combined." The more common practice is to block industrial experiments, test the significance of the block effect, and ignore it only when negligible. Analysis of covariance is also used in industry to attack this problem, but Chapter 10 overlooks the important industrial problem of changing ambient conditions or impurity levels during chemical processing.

On page 174, one statement is patently untrue. "Of course any set of more than 10 points in the experimental region will allow this fitting [of a second-order surface with 10 coefficients], but there are design considerations which improve the ease and the quality of the estimation." If the experimenter never varies two of the factors in combination with each other, it will never be possible to fit their interaction effect! I write from the pained experience of one who has attempted to extract information from large sets of experimental data generated without a sound statistical design. I shudder at the thought of a novice experimenter using this sentence out of context to justify another series of one-factor-at-a-time experiments.

Julia O'Neill
Rohm and Haas Company

REFERENCES

Bates, D. M., and Watts, D. G. (1988), *Nonlinear Regression Analysis and Its Applications*, New York: Wiley.
Box, G. E. P., Hunter, W. G., and Hunter, J. S. (1978), *Statistics for Experimenters*, New York: Wiley.
Brassard, M., and Ritter, D. (1994), *The Memory Jogger II*, Methuen, MA: GOAL/QPC.
Cochran, W. G., and Cox, G. M. (1957), *Experimental Designs*, New York: Wiley.
Daniel, C. (1959), "Use of Half-Normal Plots in Interpreting Factorial Two-Level Experiments," *Technometrics*, 1, 311–342.
Montgomery, D. C. (1996), *Design and Analysis of Experiments*, New York: Wiley.
Myers, R. H., and Montgomery, D. C. (1995), *Response Surface Methodology*, New York: Wiley.

Linear Models, Least Squares and Alternatives (2nd ed., Springer Series in Statistics), by C. Radhakrishna Rao and Helge Toutenburg, New York: Springer-Verlag, 1999, ISBN 0-387-98848-3, xv + 427 pp., $69.95.

This book presents the application of linear models to a variety of problems. The author presents a unified approach, presenting the linear model in diverse areas such as economic regression models, stochastic models, multivariate regression models, generalized linear regression models, neural networks, and logistic regression. Theoretical topics such as best estimators and convergence properties are also discussed. The presentation of topics is quick but fairly complete. The book contains a useful appendix on matrix algebra to help the reader with needed background. This book makes an excellent reference book but lacks the necessary example development to make it a valuable classroom textbook. The book could benefit from additional useful problems at the end of each chapter. Due to the great number, not all the topics discussed in the book are mentioned in this review.

The first chapter describes the chapters to follow and the discussion starts in Chapter 2. Here linear models are introduced in the form of econometric multivariate and generalized linear regression models. The structural forms are given without estimation concepts, and a small exercise set ends the chapter. The second chapter introduces the reader to specific regression model settings. Econometric models, multivariate regression, and generalized regression models are quickly introduced. The third and fourth chapters concern the linear and generalized linear regression models. Different types of least squares and maximum likelihood estimation, hypothesis testing, optimality, and Bayes solutions are presented. Mixed and fixed-effects models and misspecified models are discussed. The fifth chapter concerns stochastic linear restrictions. Restricted least squares and stochastic models are presented. The sixth chapter concerns prediction problems in the generalized linear regression model. Topics including trend analysis and optimal prediction models are discussed. Sensitivity analysis is discussed in the seventh chapter. Analysis using confidence ellipsoids and graphical techniques are presented. In the eighth chapter the case of incomplete datasets is considered. Missing data procedures as well as shrinkage estimators are presented. The ninth chapter deals with robust regression. Least absolute deviation models and m estimators are presented. The last chapter discusses techniques for categorical response. Some of the topics discussed are maximum likelihood theory, goodness-of-fit models, and contingency-table analysis. There are two helpful sections that end the book. The first is a useful presentation of matrix algebra topics, and the second is a listing and synopsis of various computer software for linear regression models.

The individual chapters contain much information that would be useful for a reader doing research in various topics in linear and generalized regression models. The presentation of topics takes a theoretical approach. Not much in the way of applied model development is presented in the main body of the text.

Dale Borowiak
University of Akron

Bootstrap Methods: A Practitioner's Guide, by Michael R. Chernick, New York, Wiley, 1999, ISBN 0-471-34912-7, xvi + 264 pp. $74.95.

This is a reference book for bootstrap methods intended for applied researchers and mathematical statisticians. The text consists of nine chapters covering estimation, confidence intervals, regression, time series, special topics, and an extensive bibliography (nearly 1/3 of the pages). This is not intended to be a course textbook, so there are no problems or exercises. Although one of the stated purposes of the book is to provide an introduction to bootstrap techniques, it is really more successful in describing applications of bootstrap methods. A strong point of this book is that it provides a historical perspective on the dramatic development of both the applications and the theory in the Historical Notes sections in each chapter.

The introductory chapter describes the evolution of the author's own interest in bootstrap methodology and includes his experience in explaining the bootstrap to the engineering community. Applications in engineering and clinical medicine are introduced. The Historical Notes is the longest part of this chapter and is an interesting account of the development of the bootstrap. Chapter 2 presents bootstrap estimation in the context of bias estimation of error rates in classification (two-class discrimination). This context was clearly determined by the author's extensive knowledge of this problem and includes references to much of his own published research. Chapter 3 describes various types of bootstrap confidence intervals and includes an example based on a clinical trial. Chapter 4 presents bootstrap methods for regression and includes an engineering-based example of bootstrap standard error estimates for nonlinear model parameters. Chapter 5 presents bootstrap techniques for forecasting and time series and completes the description of bootstrap methods.

The remaining chapters deal with more general bootstrap topics. Chapter 6 describes related methods (jackknife, delta method, cross-validation; and Bayesian, smoothed, parametric and double bootstrap techniques). Chapter 7 discusses choosing the number of bootstrap replications and variance reduction methods. Special topics in Chapter 8 include determining the number of components in a mixture and bootstrap confidence interval estimation of the C_{pk} process capability index with skewed data. The final chapter presents situations in which bootstrap techniques fail and describes a bootstrap diagnostic (jackknife-after-bootstrap).

This is not a gentle introduction to the topic but was intended to supplement material from Efron and Tibshirani (1993). Although most of the text is presented at a basic technical level, there are more advanced theoretical sections. The bibliography is extensive and references cited in the text are identified. The associated text page numbers for cited references are not included in the bibliography, but there are author and subject indexes. I found several typographical errors that the author has indicated will be corrected in future printings. In summary, this book can serve as a useful resource when trying to locate research papers on bootstrap methods and specific applications and will enhance understanding of the historical development of this important area of modern statistics.

James T. Wassell
National Institute for Occupational Safety and Health,
Centers for Disease Control and Prevention

REFERENCE

Efron, B., and Tibshirani, R. J. (1993), *An Introduction to the Bootstrap*, New York: Chapman and Hall.

Bayesian Methods, by Thomas Leonard and John S. J. Hsu, New York: Cambridge University Press, 1999, ISBN 0-521-59417-0, xiv + 333 pp., $64.95.

This book presents Bayesian inference and model building primarily using normalizing transformations for parameters that lead to approximately normal priors and likelihoods. Such transformations afford excellent posterior approximations yielding estimators with good frequentist performance. With this focus, the book differs from two other recent books on the application of Bayesian statistics, those by Carlin and Louis (1996) and Gelman, Carlin, Stern, and Rubin (1995). The latter emphasize noniterative and iterative Monte Carlo (MC) methods in the analysis of posteriors. But the difference is complementary. Users of MC methods have need of approximations like those here, making this a useful addition to any practitioner's library.

Bayesian Methods is pregnant with detailed examples, pulled primarily from recent literature, especially from contributions by the authors. Rather than serving simply as illustrations of results in the text, these examples are an integral part of the authors' development. What is more, they are interesting! They endow the theory with life and draw the reader deeper into the text.

The level of the book is consistent with its subtitle, *An Analysis for Statisticians and Interdisciplinary Researchers*. The reader should have a solid background in mathematical statistics (at the level of Casella and Berger 1990, for example) and at least some understanding of linear models and time series. In addition to familiarity with a comprehensive statistical package such as SAS or S-PLUS, facility with a good mathematical computing package such as Mathematica, Matlab, or Mathcad will be necessary to work through the exercises. The book is well suited as both a reference and for self-study. The index is thorough and the bibliography extensive, covering more than 15 $10'' \times 7''$ pages.

Combining this book with Carlin and Louis (1996) and/or Gelman et al. (1995) would form the textual basis for a superb two-semester course on Bayesian methods. A one-semester course could be taught from the book, though some material would have to be deleted and more extensive coverage of MC methods would have to be provided by the instructor. The reader is encouraged to explore further afield because virtually all examples and many of the exercises are connected to the literature. For instance, one problem entitled "Smoothing a Logistic Regression Function (a semi-parametric procedure)" covers two pages and cites over a dozen related papers (pp. 249–250). In addition to the examples in the book, there are 49 "worked examples" and 148 "self-study exercises." The worked examples are presented as problems with detailed solutions.

The book contains six chapters. In the course of 74 pages, Chapter 1 ranges across the most important results from non-Bayesian statistical inference, with an emphasis on the likelihood, its properties, and its use. The reader's need for a strong mathematical statistics background is obvious from the start. On page 8 alone, for example, the authors define the likelihood, maximum likelihood estimators, entropy, the general information criterion, Akaike's information criterion, and the Bayesian information criterion. By page 14, there are exercises referring to unbiasedness (without explanation) and at least one uses the general linear model. Later in the chapter, the authors are careful to take more time with topics that may not have been covered in a typical mathematical statistics course, like histogram smoothing and the likelihood principle. Thus, the pace of this review chapter, though brisk, should not deter most *Technometrics* readers and well-prepared students.

The discrete version of the Bayes theorem is the topic of Chapter 2. Applications include model selection, logistic discrimination, and others. An interesting feature of this chapter is a two-page exposition on the use of the Bayes theorem for the evaluation of evidence. Their advice is "[in] contrast with current standard practice in legal cases, for example, for genetic testing and DNA profiling, which gives rise for social concern at an international level" (p. 96).

The Bayes theorem is applied to models with single real-valued parameters in Chapter 3. The authors pay close attention to the elicitiation of priors and model checking. The issue of vague prior information is extensively discussed, and here arises one of the few instances where the book puzzles me a little. Noting that a scientist is rarely in a state of complete ignorance, the authors then state the fact that "The Bayesian paradigm cannot formally handle complete prior ignorance" (p. 134). Next they imply, intentionally or otherwise, that non-Bayesian methods somehow *can* handle prior ignorance: "In such situations, the scientist can use likelihood methods if there is a sampling model available" (p. 134). They immediately proceed to focus on priors that handle little or vague information, but the "damage" has been done. I can well imagine a novice inferring from this that "conservative" or "objective" analyses demand non-Bayesian methods.

Both posterior and predictive inferential methods are extensively covered in Chapter 3. Results are obtained through conjugate analyses or approximations, often requiring normalizing transformations. Everything is effectively woven together using examples presented in great detail. Like Carlin and Louis (1996), the authors place a premium on the frequency properties of inferential methods. To that end, the chapter also considers loss functions, risk functions, Bayes risk, and related ideas.

The authors describe Chapter 4 as providing "a break to some of the technicalities" (p. xii). The break comes in the form of a 23-page treatment of the expected utility hypothesis! Although the material is well presented, it is essentially basic utility and decision theory and seems very out of place in this book. I would much prefer a chapter with more extensive coverage of MC methods or a lengthy appendix covering more of the computational details. I think Chapter 4 will be the least interesting to readers of *Technometrics*. Fortunately, the uninterested reader can skip this material with no loss in continuity.

Chapter 5 returns to the main course and tackles models with several parameters. The emphasis is on marginal densities in which calculations, if not analytical, are conducted using numerical integration methods, multivariate normal approximations, conditional maximization with respect to the nuisance parameters, and Laplacian approximations, all facilitated by parameter transformations. MC methods are sometimes employed, but their more detailed treatment is saved for Chapter 6. Examples include failure-time analyses, linear logistic models, prediction for regression, inference for the negative binomial, models with interaction for contingency tables, nonlinear regression, the Kalman filter, on-line analysis of time series, Bayesian forecasting in economics, and others.

Prior structures, posterior smoothing, Bayes–Stein estimation, and MC methods are the subjects of Chapter 6, the last chapter. Over half of the chapter is devoted to the detailing of transformations and approximations that form the unifying theme of the book. Multivariate normal priors for transformed parameters are given a lengthy treatment along with Laplacian approximations using posterior mode vectors. Several approaches to constructing a multivariate normal prior are discussed, including hierarchical Bayes, parametric empirical Bayes, and the marginal posterior mode compromise. Everything is tied together with practical examples. The treatment of iterative and noniterative MC methods, covering about 26 pages, is all too brief, but consistent with the theme of the book. Here one must turn, for example, to Carlin and Louis (1996), Gelman et al. (1995), Gilks, Richardson, and Spiegelhalter (1996), or Gamerman (1997).

I strongly recommend this book to anyone interested in Bayesian methods. I look forward to using it in the classroom. It has already become one of a half-dozen or so recent books on applications of the Bayesian paradigm to which I routinely refer. The only problem is, my students are constantly borrowing them!

John W. Seaman, Jr.
Baylor University

REFERENCES

Carlin, B. P., and Louis, T. A. (1996), *Bayes and Empirical Bayes Methods for Data Analysis*, New York: Chapman and Hall (CRC Press).

Casella, G., and Berger, R. L. (1990), *Statistical Inference*, Pacific Grove, CA: Wadsworth & Brooks-Cole.

Gamerman, D. (1997), *Markov Chain Monte Carlo*, New York: Chapman and Hall (CRC Press).

Gelman, A., Carlin, J., Stern, H., and Rubin, D. B. (1995), *Bayesian Data Analysis*, New York: Chapman and Hall (CRC Press).

Gilks, W., Richardson, S., and Spiegelhalter, D. (1996), *Markov Chain Monte Carlo in Practice*, London: Chapman and Hall (CRC Press).